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10/522773
DT15 Rec'd PCT/PTO 31 JAN 2005

755-TY

DESCRIPTION

TRANSPLANT PRODUCTION SYSTEM

Technical Field

The present invention relates to a system for transplant production with multi-layer shelving in a closed space. More specifically, the present invention relates to a transplant production system using an artificial light source, an air conditioner and an automatic irrigation unit and capable of realizing a stable transplant production environment not influenced by an external environment and efficiently producing high-quality plug seedlings under a uniform growing condition.

Background Art

Conventionally, as a method for growing seedlings of various plants, there is a transplant production method represented by a plant factory. This transplant production method is a method for stably growing high-quality uniform seedling through labor-saving at a low cost by using a closed-type transplant production system including an artificial light source, air conditioner and an automatic irrigation unit to thereby artificially control the light quantity, temperature, humidity, wind speed and irrigation quantity in a transplant production space to optimum states.

As this type of closed-type transplant production system, an artificial environmental system is disclosed in Japanese

ATTACHMENT B

Patent No. 3026253. In this system, an air conditioning chamber is formed at the inside of a ceiling wall of a box-shaped outer chamber constituted by a thermal insulating material, a blowing chamber and a suction chamber are formed at the inside of the opposed side walls of the outer chamber, respectively, and transplant production boxes are removably disposed in a multi-layer manner between the blowing chamber and the suction chamber. The air in the system is blown into a transplant production space from a honeycomb-structural wall of the blowing chamber and sucked by passing through a porous-plate wall of the suction chamber, and sent to the blowing chamber again by passing through a ventilation flue in the air conditioning chamber to thereby circulate the air. The circulation air is adjusted in temperature and humidity by an air conditioner and blower positioned in the air conditioning chamber and circulated. However, in such a system described above, since the air conditioning chamber, the blowing chamber and the suction chamber are formed at the inside of the outer chamber, there is a problem that the utilization efficiency of the transplant production space in the outer chamber is deteriorated. Also, since special rectifying means for uniformly blowing air from the blowing chamber is used, the structure of the system becomes complex.

Moreover, as an automatic irrigation unit used for this type of transplant production system, there is a unit disclosed by a report entitled "Development of an injection type sub-irrigation unit for plug tray" presented in the joint meeting of three scientific societies of The Society of

Agricultural Meteorology of Japan, Japanese Society of Environment Control in Biology and Japanese Society of High Technology in Agriculture in 1999. The automatic irrigation unit reported here injects proper amounts of water and a culture solution to a culture medium for a short time by inserting a plurality of nozzle into a plug tray from the bottom holes thereof. This irrigation unit has a feature that excess water or excess culture solution is not discharged because injected water does not leak from the bottom holes of the plug tray. It is necessary in such a irrigation unit, however, to prepare a large number of nozzles to be inserted into all of the bottom holes formed on the bottom walls of tens to hundreds of plugs for a single plug tray, mechanically insert these nozzles into all of the bottom holes, and then inject an equal amount of water from each of these nozzles. Thus, in order to realize these requirements, there is a defect that a complex and expensive mechanism is required.

Further, as another automatic irrigation unit, there is a unit disclosed by a report entitled "Simplification of an automatic irrigation unit on the basis of evapotranspiration measurement of plug seedlings population" presented in the joint meeting of The Society of Agricultural Meteorology of Japan and Japanese Society of Environment Control in Biology in 2000. In this automatic irrigation unit, an amount of evapotranspiration of a plant body and a culture medium is measured as a change in seedling population weight for each plug tray by placing the plug tray on a pan balance, a switch contact point is set to a pointer of the balance, and the switch

contact point directly detects movement of the pointer to designate start of irrigation to the seedling population. This unit has a feature that irrigation using a proper amount of water can be conducted without discharging excess water, since irrigation is started on the basis of the amount of evapotranspiration and irrigation using a minimum necessary amount of water is carried out by using a subtimer. However, this report reveals that, since the operation of the pointer has a mechanical resistance and movement of the pointer is directly influenced by gravity, the operation of the pointer is incomplete or the operation accuracy thereof has a problem.

Furthermore, Japanese Patent Laid-Open Specification No. 2001-346450 discloses a sub-irrigation unit, i.e. a watering unit capable of watering from the bottom of a plug tray, for use in a transplant production system with multi-layer shelving in a closed space. This sub-irrigation unit is provided with a shallow quadrangular box having three sides surrounded by side walls and having a bottom wall face. A drainage groove is formed at the side of the box having no side wall. A water supply pipe is disposed on the side wall face of the side of the box opposed to the drainage groove. A porous sheet of a synthetic resin is put on the bottom wall face of the box and plug trays are mounted on the porous sheet. According to the sub-irrigation unit having the above-described structure, water supplied from the water supply pipe is absorbed by the porous sheet due to its capillary action and spreads to the whole of the bottom wall face of the box in a short time to thereby attain a water pool state at a predetermined water

level and uniformly supply water to culture media contained in the respective plugs from plug holes formed at the bottom of the respective plugs arrayed in the plug tray due to the capillary phenomenon. Since the culture medium in each plug becomes a water saturated state in a short time due to the capillary phenomenon, it is not necessary to keep the pool state for a long time. However, unless a pump having a large discharge quantity is used, water does not spread to the whole of the bottom wall face of the box and therefore the pool state is not realized. After irrigation is stopped, water remaining in the porous sheet is discharged to the drainage groove from an end of the porous sheet hanging down into the drainage groove. However, since the bottom of each plug contacts with the porous sheet even after irrigation is stopped, the vicinity of the plug hole is easy to keep a wet state. As a result, roots of seedling extend to the outside from the plug hole, and therefore a trouble occurs in the takeout operation of seedling from the plug, and there is a danger of damaging the roots. To prevent the roots of seedling from extending up to the vicinity of the plug hole by drying the vicinity of the plug hole after irrigation is stopped, it is proposed to form a plurality of small protrusions on the plug bottom so that the plug bottom does not directly contact with the porous sheet. However, a satisfied dry state is not always obtained.

Disclosure of the Invention

In view of the above circumstances, the inventors of the present invention have eagerly studied in order to overcome

the above-described problems present in the technical field of culturing seedling using a closed-type transplant production system and provide a transplant production technique capable of efficiently producing uniform and high-quality seedling at a low energy and a low cost. The present invention has accomplished as a result of such studies.

The following are objects of the present invention:

(1) To provide a closed-type transplant production system having a high space utilization rate in a closed space;

(2) To provide an energy-saving transplant production system capable of efficiently circulating the air in a closed space by a simple structure without using complex rectifying means and capable of realizing effective temperature and humidity control by minimum necessary power; and

(3) To provide a transplant production system having a sub-irrigation unit requiring only minimum necessary irrigation to culture seedling and capable of effectively drying the bottom of plug trays when irrigation is stopped.

A transplant production system according to the present invention comprises:

at least one air conditioner installed in a completely light shielding closed structure surrounded by a thermally insulated wall, the air conditioner controlling the temperature and humidity of air in the closed structure;

at least one box-shaped culturing module disposed in the internal space of the closed structure, the culturing module having a front face opening which is opened to the internal space of the closed structure;

a plurality of transplant production shelves arranged vertically in multi-layer in the culturing module to form a transplant production space between the upper and lower transplant production shelves;

a plurality of plug trays for holding a plant growing medium mounted on each transplant production shelf;

a sub-irrigation unit capable of irrigation from the bottom of the plug trays mounted on each transplant production shelf;

an artificial lighting unit provided on the back of each transplant production shelf, the artificial lighting unit irradiating light to the lower plug trays; and

at least one air fan fixed to the back wall of each transplant production shelf of the culturing module,

whereby the air whose temperature and humidity have been controlled by the air conditioner is sucked by the air fan from the front face opening of the culturing module and sent to the rear of the back wall of each transplant production shelf to circulate the air in the closed structure.

It is also possible that a plurality of the culturing modules are disposed in the internal space of the closed structure so that they are arranged in one line with their front face openings facing to the same direction.

Alternatively, it is possible that a plurality of the culturing modules are arranged in two lines with their front face openings in the same line facing to the same direction, and the front face openings in one line are opposed to the front face openings in the other line, and a work space and

concurrently an air circulation path is formed between the two lines of the culturing modules.

The sub-irrigation unit mounted on each transplant production shelf is preferably provided with a shallow quadrangular box-shaped irrigation tray having three sides surrounded by side walls and having a bottom wall face, a water supply pipe for supplying water into the irrigation tray is disposed in the irrigation tray, a drainage groove joined to the bottom wall face is formed at the side of the irrigation tray having no side wall, the drainage groove and the bottom wall face are partitioned by a dam, and means for holding a gap between the bottom wall face of the irrigation tray and the bottom of the plug tray at the time of mounting the plug tray on the bottom wall face of the irrigation tray is provided on the bottom wall face of the irrigation tray.

Brief Description of the Drawings

Figure 1 is a schematic plan view showing an example of a transplant production system of the present invention.

Figure 2 is a schematic longitudinal sectional view showing a flow of air in the internal space of the transplant production system shown in Figure 1.

Figure 3 is a front view showing an example of a culturing module used for the transplant production system of the present invention.

Figure 4 is a side view of the culturing module shown in Figure 3.

Figure 5 is a plan view showing an example of a sub-irrigation unit used for the transplant production system of the present invention.

Figure 6 is a perspective view of the sub-irrigation unit shown in Figure 5.

Figure 7 is a schematic longitudinal sectional view along the line X-X in Figure 5.

Figure 8 is a schematic longitudinal sectional view showing another example of the sub-irrigation unit used for the transplant production system of the present invention.

Figure 9 is a schematic plan view showing another example of the transplant production system of the present invention.

Figure 10 is a schematic plan view showing still another example of the transplant production system of the present invention.

Best Mode for Carrying Out the Invention

A preferable example of a transplant production system of the present invention is described below by referring to the example shown in Figures 1 and 2. A transplant production system of the present invention is a closed-type transplant production system constituted by arranging a plurality of box-shaped culturing modules 3, 4, 5, and 6 (four in the case of the illustrated example) in an internal space of a completely light shielding closed structure 1 surrounded by a thermally insulated wall. In the present invention, the closed structure denotes a structure having an internal space closed by being surrounded by a wall for cutting off external air

temperature and natural light. A typical structure is a box-shaped hexahedron obtained by combining reinforcing bars, slates and a thermal insulating material. The external shape of the structure is not restricted to a boxy shape. It is allowed to use a barrel shape, hemicylindrical shape or hemispherical shape.

The size of the internal space of the closed structure 1 may be determined to proper dimensions depending upon the number of culturing modules to be arranged in the internal space. In the case of the example shown in Figure 1, two culturing modules 3 and 4 are arranged in one line with their front face openings facing to the same direction. In addition, two culturing modules 5 and 6 are also arranged in one line with their front face openings facing to the same direction. These two lines of the culturing modules are disposed in the internal space of the closed structure 1 so that the front face openings in one line are opposite to the front face openings in another line. Moreover, a work space in which one or more workers can work is formed between these two lines of the culturing modules. In order to improve the area utilization rate and space utilization rate of the internal space of the closed structure 1, it is preferable to form the work space as small and narrow as possible. When the culturing modules 3 to 6 are displaced in the closed structure 1, a path of air passed through the culturing modules is formed by providing a space having a width of about 50 to 300 mm between the inside wall face of the closed structure and the backs of the culturing modules.

Concerning internal dimensions of the closed structure 1 in the example shown in Figures 1 and 2, the width is 3,400 mm, the depth is 2,500 mm, and the height is 2,200 mm. Providing an air curtain at the inside of a hinged door 2 of an entrance is preferable because it is possible to prevent outside air from coming in when a worker passes through the door 2.

The closed structure 1 is provided with an air conditioner having a function for controlling the temperature and humidity of the air in the internal space and circulating the air whose temperature and humidity have been controlled to the predetermined conditions. Indoor units 7, 8, 9, and 10 of the air conditioner are fixed to the upper portion of the inner face of the closed structure side wall and an outdoor unit (not illustrated) is positioned to the outside of the closed structure 1. One air conditioner may control the temperature and humidity of the whole internal space depending on the size of the closed structure. However, in order that the temperature-controlled and humidity-controlled air is effectively circulated in the internal space of the closed structure 1, it is preferable to use a plurality of the indoor units of the air conditioner corresponding to the number of a plurality of the culturing modules and fix each indoor unit to the upper portion of the inner face of the closed structure side wall located at the rear of the back wall of each culturing module.

As shown in Figures 3 and 4, the culturing module 3 disposed in the internal space of the closed structure 1 is provided with a boxy outer shape having side walls 3a and a back wall

3b formed on the side and back faces thereof, respectively, and having a front face opening. In the culturing module 3, a plurality of culturing shelves 12 are vertically arranged in multi-layer at certain intervals, whereby the area utilization efficiency of the transplant production space is improved. It is preferable that the height of each culturing module 3 is set to about 2,000 mm at which a worker can work, the width of each transplant production shelf 12 is set to, for example, about 1,000 to 2,000 mm at which a plurality of plug trays of synthetic resin each having tens to hundreds of plugs (small pots) arrayed in a grid pattern can be mounted and the temperature and humidity in each shelf can be controlled at a constant value, and the depth of each transplant production shelf 12 is set to 500 to 1,000 mm. Concerning external dimensions of the culturing module 3 of the illustrated example, the height is 1,650 mm, the width is 1,300 mm, and the depth is 650 mm and four plug trays 40 (refer to Figure 1) are mounted on each transplant production shelf 12. Concerning dimensions of one plug tray, the width is about 300 mm and the length is about 600 mm in general.

A plurality of transplant production shelves 12 arranged in multi-layer in the culturing module 3 (four stages in the example shown in Figure 3) are almost horizontal and a transplant production space is formed between the transplant production shelves 12. The transplant production shelf located at the lowest-stage is mounted on a pedestal 3c of the culturing module and the horizontality of the transplant production shelves 12 can be adjusted by an adjuster 3d set

on the pedestal. By decreasing the interval between the adjacent transplant production shelves and increasing the number of transplant production shelves, it is possible to improve the space utilization rate. However, when the interval between the adjacent transplant production shelves is too small, there are disadvantages that the operability for removing or inserting plug trays is deteriorated and the maximum length of seedling cannot be secured. Therefore, it is preferable that the interval is set to about 300 mm or more. The transplant production shelves 12 are formed preferably by using metallic plates, metallic net, and metallic bars.

On each of the transplant production shelves 12 are mounted a sub-irrigation unit to be described herein later and a plurality of plug trays. Further, an artificial lighting unit 13 is provided on the back of each transplant production shelf 12 to irradiate light to plants grown in the plug trays of the transplant production shelf just below the lighting unit 13. In the case of the transplant production shelf located at the highest-stage, the artificial lighting unit 13 is provided on the back of the top wall 3e of the culturing module.

A fluorescent lamp is preferable as the light source of the artificial lighting unit 13. It is possible to properly select the candlepower and length of the fluorescent lamp in accordance with the width and length of the transplant production shelf 12 and the interval between the adjacent transplant production shelves 12. For example, when the transplant production shelf having a width of 1,200 mm and a length of 600 mm is used and the interval between adjacent

transplant production shelves is 350 mm, it is possible to attach four to eight fluorescent lamps each of which has a length of 1,200 mm and a candlepower of 32 to 45 W in parallel on the back of each transplant production shelf.

As shown in Figure 3, a plurality of air fans 15 are fixed to the back wall 3b of each stage of the transplant production shelves 12. By operating the air fans 15, it is possible to generate air circulation flows shown by arrows in Figure 2 in the internal space of the closed structure 1. That is, the air whose temperature and humidity have been controlled by indoor units 7 to 10 of the air conditioner is sucked into the transplant production space of each stage of the transplant production shelves 12 from the front face opening of each of the culturing modules 3 to 6, and discharged to the rear of the back wall of each culturing modules. The air discharged to the rear of the back wall of each culturing module is sucked into the indoor units 7 to 10 of the air conditioner, and, after the temperature and humidity of the air have been controlled, blown out to the front face openings of the culturing modules 3 to 6. When two lines of the culturing modules 3 and 4 and the culturing modules 5 and 6 are arranged so that the work space is formed between them as in the example shown in Figures 1 and 2, the work space functions concurrently as an air circulation path. Therefore, it is possible to provide an effective circulation flow.

When the circulation flow passes through the transplant production shelves 12 of the culturing modules 3 to 6, the circulation flow is accompanied by water vapor evaporated from

irrigation units, culture media and plant seedlings, and also by heat discharged from the artificial lighting units 13. By controlling the temperature and humidity of the circulation flow using the indoor units 7 to 10 of the air conditioner and continuously circulating the flow, it is possible to keep the internal space of the closed structure 1 at a temperature and humidity environment optimum for plant growth.

When the width of each transplant production shelf 12 is small, one air fan 15 may be fixed to the back wall 3b of each stage of the transplant production shelves. However, such a layout is not preferable because of the occurrence of uneven ventilation when a large width of the transplant production shelf 12 is used. As shown in Figure 3, by disposing a plurality of air fans 15 in each stage of the transplant production shelf 12 (one air fan is disposed for each of four plug trays; total of four air fans in the example shown in Figures 1 and 3), it becomes possible to eliminate the uneven ventilation and uniform ventilation and uniform air circulation are realized. When a plurality of air fans are disposed, it is allowed that the air suction force per one air fan is comparatively small.

The sub-irrigation unit is mounted on each of the transplant production shelves 12 arranged in multi-layer in the culturing modules 3 to 6 and employs a system in which irrigation is carried out from the bottom of the plug trays mounted on each transplant production shelf. An example of the sub-irrigation unit is shown by a top view in Figure 5, a perspective view in Figure 6, and a sectional view in Figure

7. The illustrated sub- irrigation unit 30 is provided with a shallow quadrangular box-shaped irrigation tray 31 having three sides surrounded by side walls 31a, 31b and 31c and a bottom wall face 31d. A drainage groove 32 jointed to the bottom wall face 31d is formed at the side of the irrigation tray 31 having no side wall, and a drainage port 32a is formed at one end of the drainage groove 32. Further, a water supply pipe 33 for supplying water (a culture solution containing fertilizer) into the irrigation tray 31 is also disposed. The water supply pipe 33 may be disposed in any position as long as water can be supplied into the irrigation tray 31 from that position. In the case of the illustrated example, the water supply pipe 33 is disposed on the side wall 31a of the irrigation tray opposite to the drainage groove 32 and water is supplied from a plurality of small holes 33a formed on the water supply pipe. Moreover, the drainage groove 32 and the bottom wall face 31d are partitioned by a dam 34 and a cutout 34a is formed on a part (both ends in the case of the illustrated example) of the dam 34.

The sub-irrigation unit used in the present invention is characterized in that means for holding a gap between the bottom wall face of the irrigation tray and the bottom of the plug tray is provided. The gap is held at the time of mounting the plug tray on the bottom wall face of the irrigation tray. In the example shown in Figures 5 to 7, the gap holding means is constituted by a plurality of ribs 35 formed on the bottom wall face 31d of the irrigation tray. The ribs 35 extend in

parallel with each other to the direction of the drainage groove 32 and the plug trays 40 are mounted on these ribs 35.

It is allowed that the irrigation tray 31 is made of a metal or synthetic resin, the width and thickness of the irrigation tray 31 are substantially the same as those of the transplant production shelf 12 arranged in each stage in the culturing modules 3 to 6, and the depth is set to about 30 to 50 mm. In the example of the illustrated sub-irrigation unit 30, the dimensions are such that the drainage grooves 32 protrude from the front face openings of the culturing modules at the time of mounting the irrigation trays 31 on the transplant production shelves of the culturing modules 3 to 6 (refer to reference numeral 32 in Figure 4). By protruding the drainage groove 32 from the front face opening of the culturing module, water discharged from the drainage port 32a of the drainage groove 32 of the irrigation tray 31 mounted on each stage of the transplant production shelves 12 is easily collected and drained to the outside of the closed structure 1.

When a predetermined quantity of water is continuously supplied from the small holes 33a formed on the water supply pipe 33 of the sub-irrigation unit 30, the water is spread over the bottom wall face 31d of the irrigation tray and stopped by the dam 34 to thereby accumulate up to a predetermined water level and form a water pool state. While water is supplied from the water supply pipe 33, water leaks little by little from the cutout 34a (width of about 10 mm, for example) formed on the dam 34 into the drainage groove 32. However, by adjusting the supplied water quantity and the water quantity

leaking from the cutout, the pool state having a water level of about 10 to 12 mm can be maintained in the irrigation tray 31. In this case, by narrowing the width of the cutout to decrease the outflow of the water, the supplied water quantity can be decreased and a small water supply pump may be used. When the pool state having such a water level as described above is maintained, water is soaked up, due to capillary action, to culture media in plugs 41 from plug holes 42 formed on bottoms of the plugs 41 arrayed in the plug tray 40 mounted on the ribs 35 (average height of about 7 mm, for example) and thus the culture media in all of the plugs 41 become a water saturated state in a short time. In addition, since the culture media in all of the plugs 41 arrayed in the plug tray 40 become the water saturated state uniformly, it is unnecessary to continue irrigation any more. Thus, it is possible to apply uniform irrigation to all the plugs 41 of the plug tray 40 mounted on each stage of the transplant production shelves without accurately equalizing the water quantity supplied to each stage of the transplant production shelves 12.

When supply of water from the water supply pipe 33 is continued even after culture media in all the plugs of the plug tray become the water saturated state, excess water is drained into the drainage groove 32. After automatically stopping the supply of water, although most of the water in the irrigation tray 31 is drained in a short time to the drainage groove 32 through the cutout 34a formed on the dam 34, some water remains on the bottom wall face 31d of the irrigation tray to produce a wet state. However, since the bottom of

the plug tray 40 is raised from the bottom wall face 31d of the irrigation tray by means of the ribs 35, a gap is held between the bottom of the plug tray 40 and the bottom wall face 31d of the irrigation tray. By flowing the temperature-controlled and humidity-controlled air through the gap, the vicinity of the plug holes 42 is made to be a dry state in a short time.

When the vicinity of the plug holes 42 formed at the bottom of the plug tray 40 is kept in a wet state, roots of seedling easily extend toward the water. However, when the vicinity of the plug holes 42 is kept in a dry state, roots of seedling do not extend in the direction of the location in the dry state. This phenomenon is referred to as air pruning effect and denotes a state in which roots are pruned by using an air layer as a boundary. According to the example of the sub-irrigation unit 30 as shown in Figures 5 to 7 used for the transplant production system of the present invention, it is possible to securely bring the vicinity of the plug holes 42 into a dry state in a short time and positively generate the air pruning effect. As a result, it is possible to prevent roots of seedling from extending to the outside from the plug holes 42. Therefore, at the time of fix planting of the produced seedlings, the takeout operation from the plugs 41 of seedling becomes easy and roots are not damaged.

In the case of the example of the illustrated sub-irrigation unit 30, as shown by the sectional view in Figure 7, the bottom wall face 31d of the irrigation tray 31 is tilted in the direction of the drainage groove 32. Thereby, it is

possible to drain water to the drainage groove 32 in a short time when irrigation is stopped. Moreover, in the case where the bottom wall face 31d is tilted, it is preferable to change heights of the ribs 35 so that the top surfaces 35a of the ribs become horizontal, because the plug tray 40 mounted on the ribs can be kept horizontal.

Figure 8 shows another example of the sub-irrigation unit used for the present invention. For omitting the description, the members same as those in Figures 5 to 7 are designated by the same numerals. In the sub-irrigation unit 30' as shown in Figure 8, when the plug tray 40 is mounted on the bottom wall face 31d of the irrigation tray, an lower tray 50 is intervened between the bottom wall face 31d of the irrigation tray and the plug tray 40. The lower tray 50 has a rigidity capable of supporting the plug tray 40 having the plugs 41 containing culture media, and is provided with a plurality of small holes 51 formed on the bottom wall thereof and a plurality of protrusions 52 attached to the back face thereof. These protrusions 52 function as means for holding a gap between the bottom wall face 31d of the irrigation tray and the bottom of the plug tray 40 when the plug tray 40 is housed in the irrigation tray together with the lower tray 50.

Also in the sub-irrigation unit 30' as shown in Figure 8, when a water pool state having a predetermined water level is realized by supplying water from the water supply pipe 33, water is introduced into the lower tray 50 from the small holes 51 of the lower tray 50 and water is soaked up to culture media in the plugs 41 from the plug holes 42 formed on bottoms of

the plugs 41 of the plug tray 40 through capillary action. After stopping the supply of water from the water supply pipe 33, excess water is drained to the drainage groove 32, and a small amount of water remains on the bottom wall face 31d of the irrigation tray. Even if the bottom wall face 31d is in a wet state, the gap is held between the bottom of the plug tray 40 and the bottom wall face 31d of the irrigation tray by the protrusions 52 on the back face of the lower tray 50, and the temperature-controlled and humidity-controlled air flows through the gap to thereby make the vicinity of plug holes 42 a dry state in a short time.

Also in the case of the example in Figure 8, it is possible similarly to the case of the example in Figures 5 to 7, to drain water to the drainage groove 32 in a short time when irrigation is stopped, by tilting the bottom wall face 31d of the irrigation tray in the direction of the drainage groove 32.

The plug tray 40 mounted on the irrigation tray 31 of the sub-irrigation units 30 and 30′ mounted on each stage of the transplant production shelves 12 is formed by arraying tens to hundreds of plugs 41 in a grid pattern and integrating them into a tray shape. The width of one plug tray is 300 mm and its length is about 600 mm, and various types of plug trays are commercially available. In general, the plug tray is manufactured from a synthetic resin sheet by a forming method utilizing differential pressure. As the shape of the plug 41, an inverted frustoconical shape is preferably employed and either of a circular cone or pyramid may be used. It is

preferable to use a plug having a depth of approximately 15 to 50 mm and a capacity of approximately 4 to 30 ml and having a plug hole 42 in the bottom and capable of irrigation from the bottom.

In the case of the example of the transplant production system of the present invention shown in Figures 1 and 2, two lines of the total of four culturing modules 3 to 6, that is, a line of two culturing modules 3 and 4 and a line of two culturing modules 5 and 6, are arranged in the internal space of the closed structure 1 so that the front face openings in one line are opposed to the front face openings in the other line. Since the transplant production system of the present invention has a structure in which culturing modules are arranged in the internal space of the closed structure, it is possible to freely construct a transplant production system corresponding to a scale by properly selecting the size of the closed structure and the number of culturing modules to be arranged in the closed structure. For example, Figure 9 shows an example in which two culturing modules 3 and 4 are disposed in the internal space of the closed structure 1 so that they are arranged with their front face openings facing to the same direction. Further, Figure 10 shows an example in which one culturing module 3 is disposed in the internal space of the small closed structure 1. In Figures 9 and 10, the members same as those in Figures 1 and 2 are designated by the same numerals for omitting the description.

In the transplant production system of the present invention, it is not always necessary to fix the indoor units

7 to 10 of the air conditioner installed in the closed structure 1 to the upper portion of the inner face of the side wall of the closed structure 1 located at the rear of the back wall of the culturing modules 3 to 6. The indoor units may be fixed to any position as long as an air circulation flow can be generated in the internal space of the closed structure by means of the indoor units of the air conditioner and the air fans 15 fixed to the back wall of the culturing modules. For example, as shown by the example in Figure 10, it is also possible to fix the indoor unit 7 of the air conditioner to the inner face of the side wall of the closed structure 1 opposite to the front face opening of the culturing module 3.

Since the internal space of the closed structure has a high airtightness, in the case where the normal ventilation condition is applied, it is necessary to artificially supply carbon dioxide gas consumed through photosynthesis during culturing of seedlings. Therefore, as shown in Figure 1, a liquid carbon dioxide cylinder 16 is positioned in the outside of the closed structure 1 and a carbon dioxide analyzer (not illustrated) is positioned in the inside of the closed structure. It is possible to keep the carbon dioxide concentration in the internal space at a predetermined value by a system for discharging a necessary amount of carbon dioxide from the carbon dioxide cylinder 16 to the internal space of the closed structure in accordance with a signal sent from the carbon dioxide analyzer, when the carbon dioxide concentration in the internal space of the closed structure

measured by the carbon dioxide analyzer becomes a certain value or less.

By culturing seedling in the internal space of the closed structure using the transplant production system of the present invention, it is possible to automatically control environmental conditions such as quantity of light, temperature, humidity, carbon dioxide and water preferable to culture seedling. In addition, since all the seedlings on each of the transplant production shelves in the culturing modules with multi-layer shelving can be cultured under the same environment, it is possible to improve the uniformity of the obtained seedling quality. The seedling quality here denotes external features such as length of hypocotyl, diameter of hypocotyl, leaf color, leaf area and the like, and quality features such as forming position of floral bud, presence or absence of bolting and the like.

Industrial Applicability

According to the present invention described above, the following advantages can be obtained.

(1) By means of the indoor units of the air conditioner installed in the internal space of the closed structure and the air fans fixed to the back walls of the culturing modules, it is possible to effectively generate a circulation flow of temperature-controlled and humidity-controlled air in the internal space. Therefore, installation of complex rectifying means is not required and efficient control of temperature and humidity in the closed space can be carried

out with minimum necessary power. As a result, it is possible to provide an energy-saving and low-cost transplant production system.

(2) A circulation flow of temperature-controlled and humidity-controlled air can effectively be generated by a simple configuration in which the indoor units of the air conditioner and the air fans are disposed in the internal space of the closed structure. Therefore, since it is unnecessary to form an air conditioning chamber, a blowing chamber, a suction chamber and the like in the internal space, a wide space for culturing seedling can be provided and as a result, the space utilization rate can be improved.

(3) By using the sub-irrigation unit having the dam formed on the bottom wall face of the irrigation tray, a water pool state having a predetermined water level can be easily realized. Thus, since culture media in all plugs of the plug tray can be brought into a water saturated state in a short time by soaking up water from the bottom of the plugs, an amount of irrigation can be minimum necessary.

(4) By using the sub-irrigation unit providing with the gap holding means between the bottom wall face of the irrigation tray and the bottom of the plug tray, a gap can be held between the bottom of the plug tray and the bottom wall face of the irrigation tray at the time of stopping irrigation and the vicinity of the plug holes can be brought into a dry state by circulating the temperature-controlled and humidity-controlled air through the gap. As a result, it is possible to prevent roots of seedling from extending from the

plug holes to the outside and simplify the operation for taking out seedling from the plug.